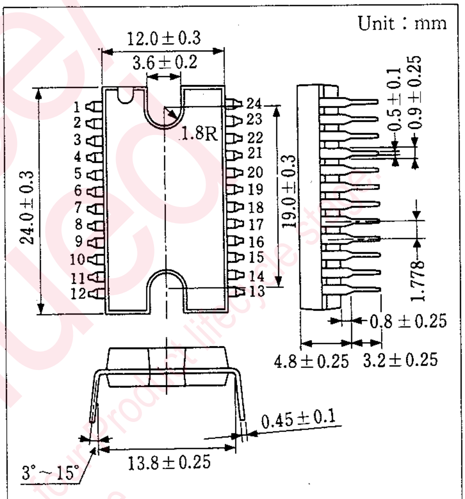
AN8210NK

IC for FDD Spindle Motor Control

■ Outline

The AN8210NK is an integrated circuit designed for control of an FDD spindle motor. Because the digital servo and linear 3-phase full-wave driving system are used, it assures no adjustment, motor rotating precision with low drift and great reduction of external components.

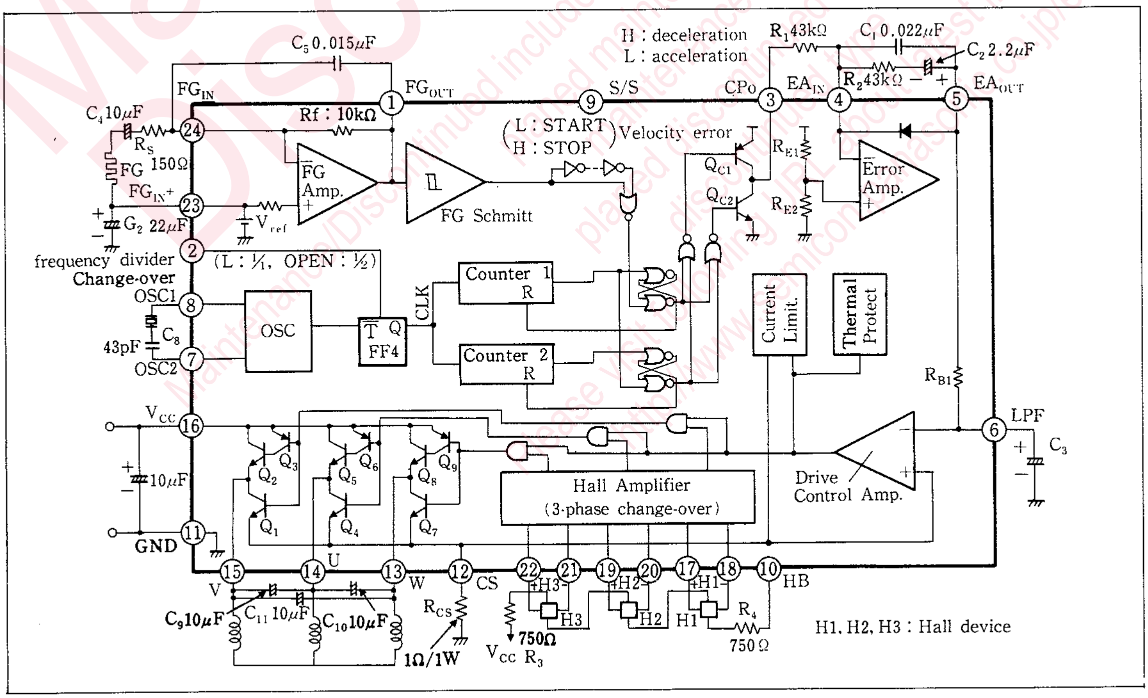


24-Lead Shrunk DIL Plastic Package(Power Type)

■ Features

- Speed control by digital velocity detector
- 3-phase full-wave current drive
- Motor current limit built-in
- Thermal protect built-in
- Start/stop switch
- Count switch-over (1/1, 1/2)

■ Block Diagram



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■ Pin

Pin No.	Pin Name	Pin No.	Pin Name
1	FG Amp. Output	13	Motor Driving Output W
2	Count Switch-over	14	Motor Driving Output U
3	Verocity Error Output	15	Motor Driving Output V
4	Error Amp. Inversion Input	16	V_{CC}
5	Error Amp. Output	17	Hall Amp.1+Input
6	Low-pass Filter	18	Hall Amp.1−Input
7	Oscillation Circuit 2	19	Hall Amp.2+Inut
8	Oscillation Circuit 1	20	Hall Amp.2−Input
9	Start/Stop Switching	21	Hall Amp.3−Input
10	Hall Element Bias	22	Hall Amp.3+Input
11	GND	23	FG Amp.+Input
12	Current Sensing	24	FG Amp.−Input

■ Absolute Maximum Ratings (Ta=25℃)

Item	Symbol	Rating	Unit
Supply Voltage	V_{CC}	20	V
Supply Current	I_{CC}	900	mA
Motor Drive Pin Voltage	V_{13}, V_{14}, V_{15}	20	V
Pin Applied Voltage	$V_1 \sim V_9, V_{24}$	−0.3～+5.5	V
Hall Amp. Input Pin Applied Voltage	$V_{17} \sim V_{22}$	0～V_{CC}	V
Circuit Current 1	I_{12}	−900～0	mA
Motor Drive Pin Current	I_{13}, I_{14}, I_{15}	−900～+900	mA
Circuit Current 2	I_{23}	−20～+1	mA
Power Dissipation	P_D	2.5	W
Operating Ambient Temperature	T_{opr}	−20～+75	℃
Storage Temperature	T_{stg}	−55～+150	℃

■ Electrical Characteristics (Ta=25℃)

Item	Symbol	Test Circuit	Condition	min.	typ.	max.	Unit
Quiescent Current at Standby	I_{QS}	1	$V_{S/S}=2V$		0.3	0.5	mA
Quiescent Current at No-load	I_{QN}	1	$V_{S/S}=0V$		18	25	mA
Reference Voltage Part							
Reference Voltage	V_{OR}	2	$I_{OR}=0mA$	2.3		2.8	V
Output Sink Current	I_{OR}	2		0.5			mA
Output Source Current	I_{OR}	2			−15	−10	mA
Output Impedance	Z_{OR}	2	$I_{OR}=0\sim-10mA$		5	10	Ω
FG Amp./Schmitt Part							
Offset Voltage	V_{OSF}	3		−15		15	mV
Feedback Resistance	R_{FF}			7.5	10	12.5	kΩ
Output Sink Current	I_{OF}	4	$V_S=0V,\ V_R=3V$	3			mA
Output Source Current	I_{OF}	4	$V_S=0V,\ V_R=2V$			−3	mA
Gain Bandwidth Product	f_{GBF}	4	$V_R=V_{OR},\ I_{OF}=0mA$		1		MHz
Oscillator Circuit Part							
Oscillation Frequency Temperature Change	$\Delta f/\Delta T$	5			−10		ppm/℃

■ Electrical Characteristics (cont'd) (Ta = 25℃)

Item	Symbol	Test Circuit	Condition	min.	typ.	max.	Unit
Speed Error Detection Part							
Count Change-Over Voltage	V_{CT}	6		1.0	1.8	2.5	V
Max. Clock Frequency	f_{max}	6		800			kHz
No. of Count 1	N_{CT1}	6	$V_{CT}=0V$		1022		Times
No. of Count 2	N_{CT2}	6	$V_{CT}=2.5V$		2046		Times
Speed Error Output Part							
Output Low Voltage	V_{OLC}	7			0.1	0.3	V
Output High Voltage	V_{OHC}	7		4.4		5.5	V
Output Sink Current	I_{OC}	7		300			μA
Output Source Current	I_{OC}	7				−150	μA
Error Amp. Part							
Output Sink Current	I_{OE}	9		2			mA
Output Source Current	I_{OE}	9				−2	mA
Gain Bandwidth Product	f_{GBF}	9			800		kHz
Output Residual Voltage	V_O		$V_{S/S}=4.5V$, Pin⑤—GND			70	mV
Drive Control Amp. Part							
Threshold Voltage	V_{THD}	10		2.3	2.55	2.8	V
Drive Gain	A_{CD}	10		1.6	1.8	2.0	Times
Emitter Voltage	V_{LD}	10		0.59	0.66	0.72	V
Open Loop Drive gain	A_{OD}				30		dB
Hall Amp. Part							
Phase Input voltage Range	V_{ICH}			2		$V_{CC}-2$	V
Drive Input voltage Range	V_{IDH}					400	mV
Hall Input Sensitivity	V_{ISH}				10		mV
Hall Offset Voltage	V_{OSH}	11				20	mV
Input Bias Current	I_{BH}	12			1.0	5.0	μA
Drive Output Part							
Saturation (Upper)	V_{SU}	13			1.2	1.4	V
Saturation (Lower)	V_{SL}	13			0.75	1.1	V
Leak Current at OFF	I_{LO}	13		−20		20	μA
Start/Stop Control Part							
Input Low Voltage	V_{IL}					0.7	V
Input High Voltage	V_{IH}			2.0			V
Input Low Current	I_{IL}	14	$V_{S/S}=0V$	−100	−50		μA
Input High Current	I_{IH}	14	$V_{S/S}=2V$		10	100	μA
Protection Circuit							
Protection Operating Point	T_P				150		℃
Hysteresis Width	T_{HP}				25		℃
FG Amp./Schmitt Part							
FG Frequency	f_{FG}	6		499.5	500.0	500.5	Hz
FG Frequency Supply Voltage Change	$\Delta f_{FG}/\Delta V_{CC}$	6				100	ppm/V
FG Frequency Load Change	$\Delta f_{FG}/\Delta L$	6				0.05	%

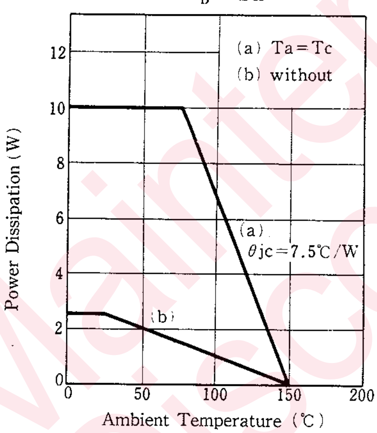
■ Electrical Characteristics (Cont'd) (Ta=25℃)

Item	Symbol	Test Circuit	Condition	min.	typ.	max.	Unit
Drift at Lapse of Rotating Speed	ΔN*		Standard motor mounted			0.1	%
FG Amp./Schmitt Part							
Open Loop Gain	A_{VF}*		$V_R = V_{OR} \cdot I_{OF} = 0mA$	70	80		dB
Schmitt width	V_{SS}*			15	25	50	mV
Speed Error Output Part							
Open Loop Gain	A_{VE}*			65	75		dB
Output Leak Current	I_{LC}*	7				0.1	μA
Input Bias Current	I_{BE}*	8				0.1	μA
Quienscest High Breakdown Level	V_S*		Applied between GND and each pin (C=100pF, No R)	300			V

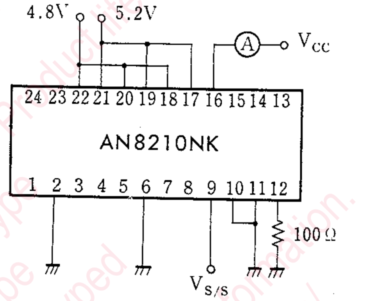
Note) Operating Supply Voltage Range : $V_{CC(opr)} = 9 \sim 16V$

* These values are of reference values for design but not for guaranteed values.

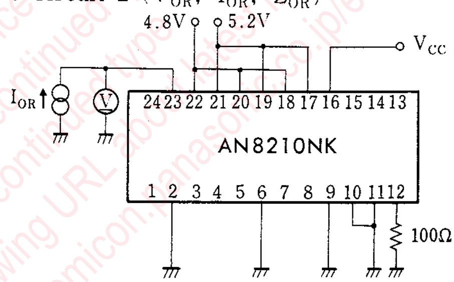
P_D—Ta



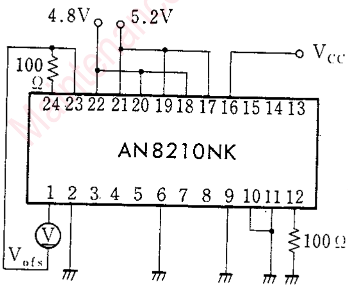
Test Circuit 1 (I_{QS}, I_{QN})



Test Circuit 2 (V_{OR}, I_{OR}, Z_{OR})

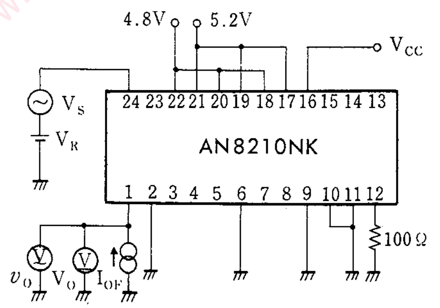


Test Circuit 3 (V_{OSF})



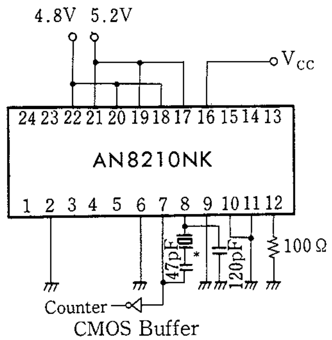
$$V_{OSF} = \frac{V_{ofs}}{100}$$

Test Circuit 4 (I_{OR}, f_{GBF})



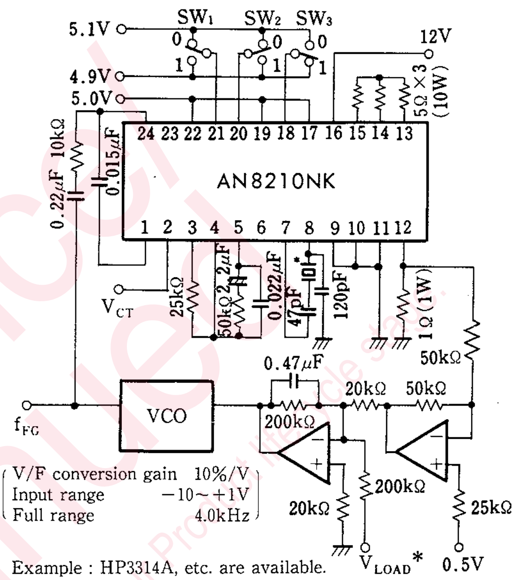
(When output sink current $I_{OF} = 3mA$, $V_O < 1.7V$ ($V_R = 3V$, $V_S = 0V$)
When output source current $I_{OF} = -3mA$, $V_O > 3.2V$ ($V_R = 2V$, $V_S = 0V$)
Open loop gain $A_{VF} = 20\log(v_O/V_S)$)

Test Circuit 5 ($\Delta f/\Delta T$)



● Ceramic resonator is used. (512kHz)

Test Circuit 6 (V_{CT}, $f_{max.}$, N_{CT1}, N_{CT2}, f_{RG}, $\Delta f_{RG}/\Delta V_{CC}$, $\Delta f_{RG}/\Delta L$)

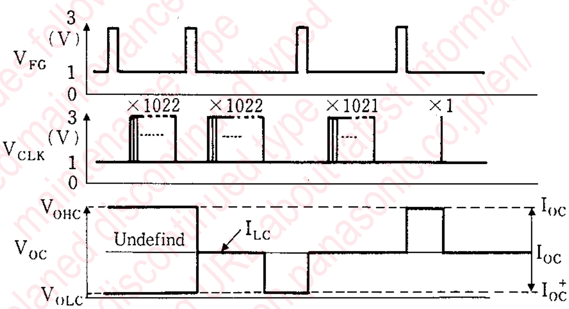


(V/F conversion gain 10%/V
Input range −10～+1V
Full range 4.0kHz)

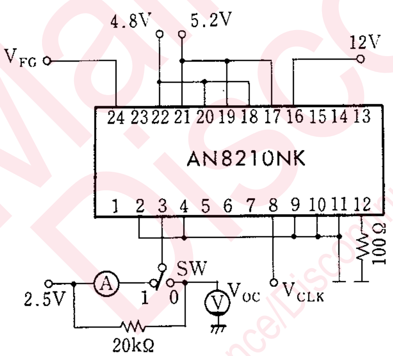
Example : HP3314A, etc. are available.

● Ceramic resonator (512kHz)

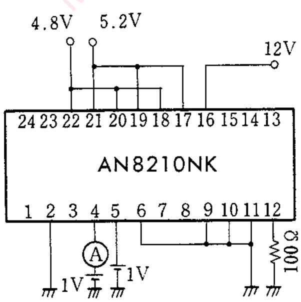
V_{FG}, V_{CLK} and Speed Error Output Timing Chart



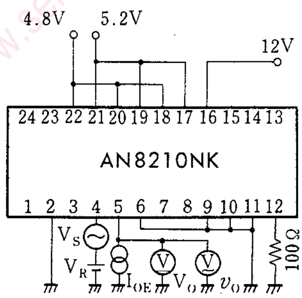
Test Circuit 7 (V_{OLC}, V_{OHC}, I_{OC}, I_{LC})



Test Circuit 8 (I_{BE})

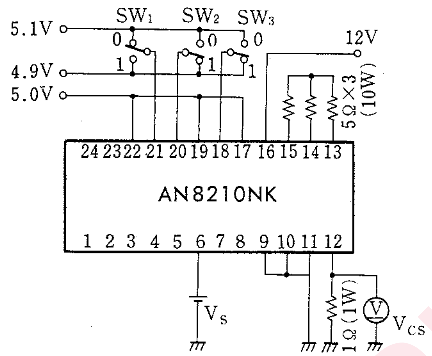


Test Circuit 9 (I_{OE}, f_{GBE})

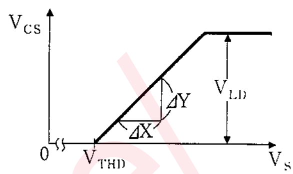


(When output sink current $I_{OF}=2mA$, $V_O<1.6V$ ($V_R=3V$, $V_S=0V$)
When output source current $I_{OF}=-2mA$, $V_O>1.8V$ ($V_R=2V$, $V_S=0V$)
Open loop gain $A_{VE}=20\log(v_O/V_S)$)

Test Circuit 10 (V_{THD}, A_{CD}, V_{LD})



$V_S - V_{CS}$ Input/Output characteristics



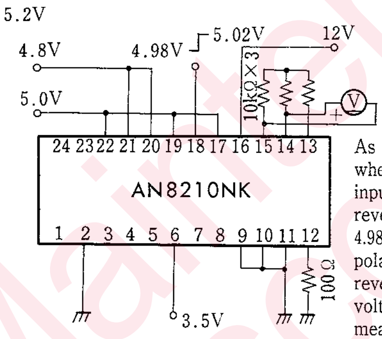
Drive gain $ACD = \Delta Y/\Delta X$ ($\Delta X = 0.2V$)

Measure each point (V_{THD}, A_{CD}, V_{LD}) in the figure right.

Item	SW_1	SW_2	SW_3
1	1	0	1
2	1	1	0
3	0	1	1

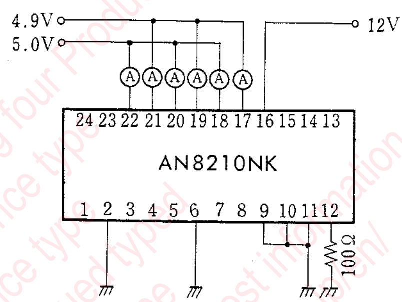
At the same time, change over switches SW_1 to SW_3 as shown in figure left and measure points described above for each item.

Test Circuit 11 (V_{OSH})

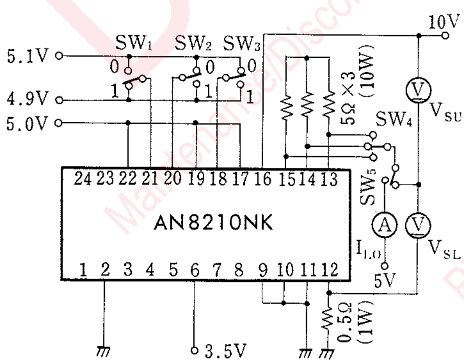


As shown in the figure left, when all polarity of hall amp. input ⑳/㉑ and Pin ⑱ are reversed from 5.2V to 4.8V and 4.98V to 5.02V respectively, the polarity of drive output is reversed, checking the offset voltage of Pin ⑱. Similarly, measurement is made for each phase.

Test Circuit 12 (I_{BH})



Test Circuit 13 (V_{SU}, V_{SL}, I_{LO})

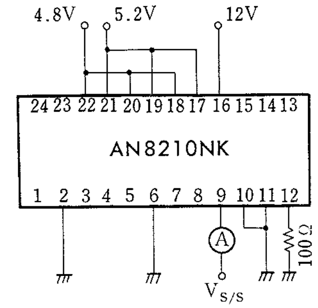


Logical Table of Phase Change-over (Hall Input-Drive Output Logic)

No.	SW_1	SW_2	SW_3	13(W)	14(U)	15(V)
1	1	1	1	off	off	off
2	1	1	0	off	H	L
3	1	0	1	H	L	off
4	0	1	1	L	off	H
5	1	0	0	H	off	L
6	0	1	0	L	H	off
7	0	0	1	off	L	H
8	0	0	0	off	off	off

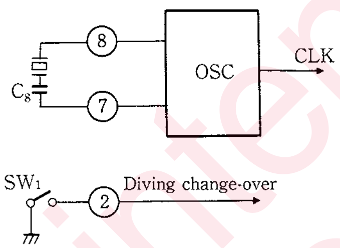
According to the logical table above, determine outputs for Pins ⑬ to ⑮ to appropriately select SW_4 or SW_5 for measurement.

Test Circuit 14 (I_{IL} , I_{IH})



■Operation Explanation

1. Oscillator



According to oscillating frequency of the oscillator, set the rotating speed of a motor.
Ceramic vibrator is used as resonator so that oscillation from 190kHz to 1MHz may be available.
Some 10pF is used for capacitor C_8 capacitance. Fine-adjustment of oscillating frequency is made possible according to capacitance values.
When using an external clock, input is made from Pin ⑧.
Division of clock frequency can be switched in "Low" or "Open" by using Pin ② and the count number of an internal counter can be changed. In this case, the equivalent counter number is N=1022 when SW_1 is in Low and N_C=2046 when SW_1 is in Open.
The rotating speed of a motor N can be obtained by the following equation.

$$N \simeq 60 \cdot \frac{f_{osc}}{N_C \cdot Z} \quad \text{(rpm)}$$

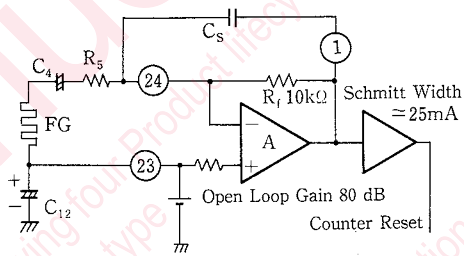
fosc: Oscillating frequency (Hz)

N_C : Equivalent count number $Nc = \frac{f_{osc}}{f_{FG}}$

Z : FG tooth number

f_{FG} : FG frequency (Hz)

2. FG Amp. Schmitt Circuit



The figure above is an example of an internal block and external circuit of Schmitt circuit.
DC operation of FG amp. is follower. However, when the circuit as shown in the figure above is used, AC operation is an inverted circuit. Gain Av is as shown below.

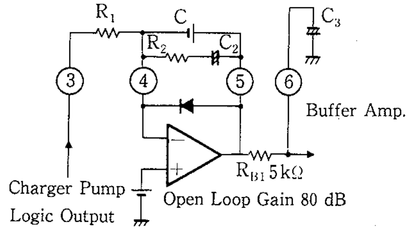
$$Av \simeq -R_f/R_5 \ (R_f \simeq 10k\Omega)$$

Gain should be set within the range of amp. output swing (1~4 V typ).
High pass and low pass filters should be configured with C_4, R_5 and C_5, R_f respectively, excluding noise elements.
Cutt-off frequency for each filter f_{CH} and f_{CL} will be as follows.

$$f_{CH} \simeq 1/2\pi \ C_4 \ R_5, \quad f_{CL} \simeq 1/2\pi \ C_2 \ R_f$$

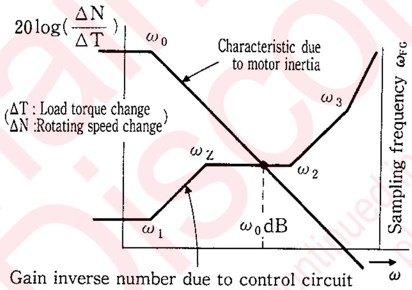
If FG frequency is f_{FG}, set so as to be $f_{CH} < f_{FG} < f_{CL}$.
For C_{12}, FG is made by DC bias; thus, is used for AC grounding purpose.

3. Error Amplifier Part



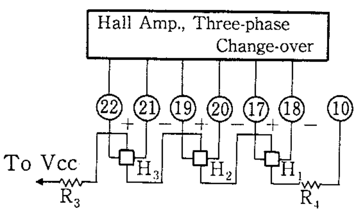
In the error amp. part, the speed detection error is made smooth and amplified. Main characteristics súch as control system stability, transient characteristics, etc. are determined in this part.
Each constant is determined as follows.
Bode diagram of control system is shown below. For an increase of characteristics in low frequency area, the mirror integrator is combined with phase-lead-lag compensation. Frequency at each pole and zero-point will be as follows.

ω_0 : 1/(Constant for motor)
ω_1 : 1/(Constant for mirror integrator)
ω_Z : $1/C_2R_2$
ω_2 : $1/(C_1//C_2)R_2$
ω_3 : $1/C_3R_{B1}$



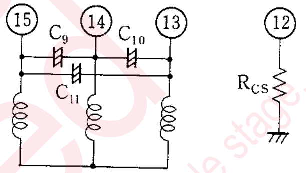
Points should be set so that frequency of gain intersection ω_0dB may be $\omega_Z < \omega_0\text{dB} < \omega_2$. With this, stability of cotrol system can be guaranteed.
Normally, $k_1 = \omega_2/\omega_Z = 10$ (approx.) and $k_2 = \omega_{FG}/\omega_0$ dB>20 are set.
For w_3, wow and flutter are increased addtionally.

4. Hall Amp.



Hall amp., Three-phase Change-over
Hall amp. performs three-phase change-over upon input of hall elements.
Input sensitivity in this case is approximately 10 mV. Current to be flowed to hall elements are set by resistors R_3 and R_4. At this time, if GND side is connected to Pin ⑩, hall current can be turned OFF in Standby mode.

5.Driber



Driver output is connected, for example, as shown in the figure above. Motor coil current is set by resistor R_S. Because electric potential of Pin ⑫ is internally set to limit level (≒0.66V), it can be used as a current limiter with R_{CS} value.

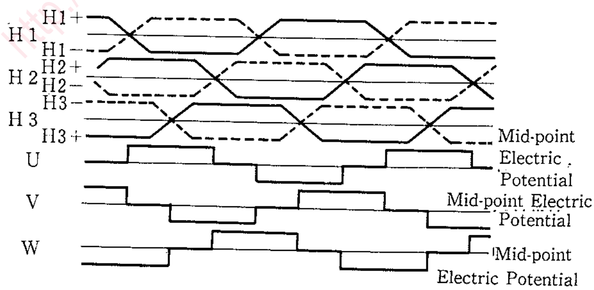
6. Heart Protection

Virtual junction temperature of IC is about 150℃ and driver current becomes Cut-off. Thereafter, reversion is made in about 25℃ of hysteresis width.

7. Start/Stop Mode

Motor rotation can be started/stopped by Pin ⑨.
Since logical level is compatible with TTL standard, motor can operate at low input current even in CMOS.
Start and stop can be accomplished in Low and High respectively.
Current consumption at stop (Standby mode) is very small, current of 500 μA or less including hall current is made possible.

(Eatch Terminal Voltage Waveform)



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